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Profit Inefficiency among Hybrid Rice Farmers in Central Vietnam

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Abstract

This paper aims to investigate the profit inefficiency among hybrid rice farmers in Central Vietnam using stochastic frontier analysis method with a stochastic translog normalized profit frontier function. The results showed that the average profit efficiency was 0.63, implying 0.37 was profit inefficiency. The research found that age, education, irrigation, share of rice income, share of hybrid rice area, frequency of training attendance, experience, and topography are robust factors contributing to profit inefficiency. To enhance farmers' profit efficiency, policies to improve educational level, increase training about hybrid rice production, improve irrigation system, and promote hybrid rice intensive production should be reinforced.

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Keywords: Profit inefficiency, Hybrid rice, Central Vietnam

1. Introduction

Agriculture is an important sector in Vietnam's economy, it contributes to 18.38% of GDP (about 31.19 billion USD, present price) and supports jobs for about 46.81% of labor force (24,44 million labors). In agricultural sector, rice is a staple crop accounting for 87.07% of total cultivation area (7.90 million hectares), constituting of 89.46% (44.08 million tons) of total grain outputs, and contributing 2.89 billion USD (worth FOB) to the export value (6.68

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million tons) (GSO, 2013). However, the main rice-cultivation areas are distributed in the North with Red River Delta and in the South with Mekong River Delta. Whereas in Central Vietnam, productive conditions are poor, and the majority of agricultural land is upland and mountainous; rice-cultivation area only makes up 4.35% of the total land area (GSO, 2013), and is small-scaled and fragmented. This results in the issue of household food security. Thanks to the advancements in science and technology, especially innovation of high yielding varieties, such as hybrid rice, the innovations play an important role in hunger eradication, poverty alleviation, and national food security. According to the assessment of Ministry of Agricultural and Rural Development Vietnam, hybrid rice is somewhat tolerant to insects and severe production conditions such as salinity, drought, and cold weather better than conventional varieties. These characteristics of hybrid rice are suitable to Central Vietnam. The statistic results show that hybrid rice has yield advantage from 29.21% to 51.89% compared with conventional varieties (GSO, 2010). The same is true in other major rice-growing countries where the rate of hybrid rice adoption is high. For example, in China hybrid rice has an average yield more than 20% compared with inbred varieties (Yuan, 2004). From 2001 to 2007, it was found that the yield of hybrid rice in the Philippines is 33% more than that of inbred seeds; 14% in Bangladesh; 12-48% in Myanmar (Vien and Nga, 2009), and 24-36.4% in India (Xie, 2011).

However, the profit of hybrid rice cultivation in Vietnam is unattractive, which can be observed by a decreasing rate of hybrid rice adoption in recent years. The study of Vien and Nga (2009) in the Red River Delta of Vietnam showed that the profit of hybrid rice is approximately 3% more than that of conventional rice, whereas the research of Xie (2011) found that the hybrid rice contributed profit to rice farmers from 12.8-34.5% higher than inbred varieties did in India. In Central Vietnam where household food security is a concern, sustainability of hybrid rice cultivation cannot be achieved without economic viability. This raised to the question whether hybrid rice farmers achieved profit efficiency (profit maximization). If not, what are the inhibitors and what is needed to be done to solve this problem? Therefore, this paper aims to explore how profit efficient are hybrid rice farmers in Central Vietnam, and to identify factors contributing to their profit inefficiency. Hence, policy implications are drawn to enhance profit efficiency for hybrid rice farmers in Central Vietnam.

2. Materials and Methods

2.1 Measuring profit efficiency using stochastic frontier profit function

Profit efficiency is defined as profit gain from operating on the profit frontier, taking into consideration farm-specific prices and fixed factors; in other words, the ratio of actual profit to the maximum profit. Thus, the standard against their performance is the profit frontier. The properties of profit function are imposed before estimating profit efficiency. In particular, (1) farmers' hybrid rice production function is assumed as continuous differentiable and concave. The profit function is (2) assumed convex and homogeneous[2] of degree 1 in input and output prices for given fixed factor (Z); (3) non-decreasing in output price and non-increasing in input prices for given Z; and (4) non-decreasing, concave, and homogeneous of degree 1 in Z for given input and output prices (Kumbhakar and Lovell, 2003). Besides, (5) the input and output markets are also assumed as perfectly competitive (or rice farmers are price takers). The normalized actual frontier profit[3] function of n farm is expressed as follows:

$$\pi_i = f(P_{ji}, Z_{ji}, \beta_j) \,.\, \exp(v_i - u_i) \qquad i = 1, 2, \ldots n; j = 1, 2, \ldots m \tag{1}$$

where π_i is the normalized actual profit of the i-th farm; P_{ji} is the vector of the j-th normalized input price[4] of the i-th farm; Z_{ji} is the vector of the j-th fixed-input factor of the i-th farm; β_j is the unknown parameters needed to be estimated; $(v_i - u_i)$ is composite error term, v_i are random variables which are assumed to be identical independently

[2] Homogeneous of degree 1 was imposed by normalizing profit and input prices by output price
[3] The normalized actual profit of the i-th farm is computed as gross revenue less variable cost, divided by the output price of i-th farm.
[4] The j-th normalized input price of i-farm is computed as the j-th input price of i-th farm divide the output price of i-th farm.

distributed (iid) ~ $N(0, \sigma^2_v)$ and are assumed to capture the effects of statistical noise, u_i are non-negative random variables accounting for profit inefficiency and are assumed to be iid as truncated at zero ~ $N(0, \sigma^2_u)$ distribution, and u_i are expressed as a function:

$$u_i = \delta_0 + \sum_{h=1}^{l} \delta_h X_{hi} \qquad h = 1, 2, \ldots l \qquad (2)$$

where δ_0 and δ_h are unknown parameters; X_{hi} is the vector of explanatory variables of the profit inefficiency.

The profit efficiency of the *i*-th farm in the context of the stochastic profit frontier function is expressed as the ratio of actual profit to the predicted maximum profit for a best-practiced rice farmer, and is written as follows:

$$\text{Profit Efficiency } (\pi E_i) = \frac{\pi_i}{\pi_{max}} = \frac{\pi_i = f(P_{ji}, Z_{ji}, \beta_j) \,.\, \exp(v_i - u_i)}{\pi_i = f(P_{ji}, Z_{ji}, \beta_j) \,.\, \exp(v_i)} \qquad (3)$$

$$= \exp(-u_i)$$

$$= \exp(-\delta_0 - \Sigma\delta_h X_{hi})$$

where πE_i takes the value between 0 and 1. If $u_i = 0$, a farm performs on the frontier, obtaining potential maximum profit. If $u_i > 0$, a farm operates inefficiently and loses some profit. This is due to the combination of technical, allocative, and scale inefficiencies.

The variance of the random errors, σ^2_v, that of the profit inefficiency, σ^2_u and overall variance of the model, σ^2, are related; thus, $\sigma^2 = \sigma^2_v + \sigma^2_u$, measure the total variation of profit from the frontier which can be attributed to profit inefficiency (Battese and Corra, 1977). Battese and Coelli (1993) provided a log likelihood function after replacing σ^2_v and σ^2_u with $\sigma^2 = \sigma^2_v + \sigma^2_u$ and thus estimating the share of inefficiency in the overall residual variance (γ) as $\gamma = \sigma^2_u/(\sigma^2_v + \sigma^2_u)$. The parameter γ takes the values in range between 0 and 1. A value of γ close to 1 suggests the existence of profit inefficiency, whereas a value of 0 can be interpreted as no evidences in the existence of profit inefficiency. The hypothesis of profit inefficiency existence is tested by Likelihood Ratio (LR)[5] test with the following hypothesis, H_0: $\gamma = 0$, and H_1: $\gamma > 0$. The stochastic profit frontier function and the inefficiency model are simultaneously estimated using FRONTIER 4.1c (Coelli, 1996). A two-stage estimation method is used in obtaining the final maximum likelihood estimation.

2.2 Data

The farm-level data are collected from a face-to-face interview with 328 rice farmers in Central Vietnam for winter-spring season of 2012/2013. A three-stage stratified random sampling method is adopted. In the first stage, the study site is stratified into two stratums comprising major and minor zones based on the rate of hybrid rice adoption in Vietnam at 10% threshold (the rate of hybrid rice adoption may affect on profit efficiency). In the second stage, major and minor zones are stratified based on the existence of hybrid-rice seed production centers. In the final stage, from selected provinces in the second stage, four districts namely Tinh Gia district of Thanh Hoa Province, Quynh Luu district and Dien Chau district of Nghe An province, and A Luoi district of Thua Thien Hue province are randomly drawn for selected hybrid rice farmers.

[5] $LR = -2(LLF_0 - LLF_1)$, where LLF_1 is value of Log Likelihood achieved by estimating unrestricted model and LLF_0 is value of Log Likelihood achieved by estimating restricted model. Reject H_0 (γ=0) if $LR > \chi_R^2$ table value, where R = number of restrictions.

2.3 Empirical model

This study uses a translog functional form (flexible functional form) to estimate profit efficiency of hybrid rice production among farmers. Based on Equation (1), after being normalized by the output price, the stochastic translog normalized frontier profit function of *n* hybrid rice farm is specified as:

$$\ln\pi_i = \beta_0 + \sum_{j=1}^{4}\beta_j \ln P_{ji} + \alpha_1 \ln Z_i + \tfrac{1}{2}\sum_{j=1}^{4}\sum_{k=1}^{4}\beta_{jk}\ln P_{ji}\ln P_{ki}\ \tfrac{1}{2}\,\alpha_{11}(\ln Z_i)^2 + \sum_{j=1}^{4}\gamma_{j1}\ln P_{ji}\ln Z_i + (v_i - u_i) \qquad i = 1, 2, \ldots .n \qquad (4)$$

where P_{ji} is the normalized-price vector of *j*-th input used by *i*-th farm including (1) the normalized prices of seed (P_{Seed}, USD/kg), (2) fertilizer[6] ($P_{Fertilizer}$, USD/kg), (3) labor (P_{Labor}, USD/man-day), and (4) pesticide[7] ($P_{Pesticide}$, USD/packet); Z_i is rice farming area (FSIZ, hectare), the quasi-fixed input; v_i are random variables which are assumed to be identical independently distributed (iid) ~ $N(0, \sigma^2_v)$ and are assumed to capture the effects of statistical noise; u_i are non-negative random variables accounting for profit inefficiency and are assumed to be iid as truncated at zero ~ $N(0, \sigma^2_u)$ distribution, and the profit inefficiency (u_i) is expressed as a following linear function:

$$u_i = \delta_0 + \sum_{h=1}^{15}\delta_h X_{hi} \qquad h = 1, 2, \ldots n \qquad (5)$$

where X_{hi} is the vector of *h*-th explanatory variable of *i*-th farm including (1) Age of household head (year), (2) Household size (person), (3) Educational level of household head (year of schooling), (4) Farming experience of household head (year), (5) Rice-cultivated area of household (hectare), (6) Irrigation (%), (7) Share of rice income in household's total income (%), (8) Share of rice for sale (%), (9) Share of hybrid rice area (%), (10) Frequency of training attendance about hybrid rice production (times/year), (11) Hybrid rice production experience of household head (year), (12) Number of family labors for hybrid rice production (person), (13) D1_Topography of farm (dummy variable, =1 if lowland; =0 otherwise), (14) D2_Type of seed (=1 if 3 lines; =0 if 2 lines), and (15) D3_Source of seed (=1 if domestic; =0 otherwise).

3. Results and Discussions

3.1 Profit efficiency

The coefficient estimates of stochastic translog normalized frontier profit function and the results of hypothesis testing of the existence of inefficiency are presented in Table 1. The estimation value of γ is equal 0.9892 (close to 1), and is significantly different from zero (statistically significant at 1%). Therefore, H_0 ($\gamma = 0$) is rejected and accept H_1 ($\gamma > 0$); this can be concluded that there is an existence of profit inefficiency in hybrid rice production among farmers in Central Vietnam. The estimated result also shows that the average profit efficiency of hybrid rice production in Central Vietnam is 0.63, it implies that farmers can increase their profit of hybrid rice production by 0.37 by improving the determinants of profit inefficiency.

This result is similar to the result of Kolawole (2006) in Nigeria with the average profit efficiency of 60%. However, it is lower compared to the results found in Ghana, Bangladeshi, and Brunei Darussalam. The average profit efficiency of rice farmers was found at 73% in Northern Ghana (Abdulai and Huffman, 1998), 77% in Bangladeshi (Rahman, 2003), and 81% in Brunei Darussalam (Galawat and Yabe, 2012).

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[6] Because farmer simultaneously uses different types of fertilizers; therefore, price of fertilizer = (price of *f*-th fertilizer * quantity of *f*-th fertilizer)/(total quantity of fertilizer used by farmer *i*-th)

[7] Price of pesticide = (price of *y*-th pesticide * quantity of *y*-th pesticide)/(total quantity of pesticide used by farmer *i*-th)

Table 1. Parameter estimates of translog stochastic profit frontier function

Variable	Coefficient estimates	T-statistics
Constant	- 5.6832	- 0.82
$\ln P_{Seed}$	0.8214	0.48
$\ln P_{Fertilizer}$	- 3.6661	- 1.09
$\ln P_{Labor}$	5.3549	0.98
$\ln P_{Pesticide}$	- 2.8745***	- 2.86
ln FSIZ	3.3787***	2.93
$1/2(\ln P_{Seed})^2$	0.2674	0.92
$1/2(\ln P_{Fertilizer})^2$	0.0420	0.03
$1/2(\ln P_{Labor})^2$	- 0.8609	- 0.38
$1/2(\ln P_{Pesticide})^2$	0.1210	0.74
$1/2(\ln FSIZ)^2$	- 0.0345	- 0.34
$\ln P_{Seed} \times \ln P_{Fertilizer}$	0.5279	1.01
$\ln P_{Seed} \times \ln P_{Labor}$	- 0.6022	- 0.94
$\ln P_{Seed} \times \ln P_{Pesticide}$	- 0.1342	- 0.92
$\ln P_{Fertilizer} \times \ln P_{Labor}$	0.3885	0.28
$\ln P_{Fertilizer} \times \ln P_{Pesticide}$	- 0.1208	- 0.34
$\ln P_{Labor} \times \ln P_{Pesticide}$	0.9741**	2.70
$\ln P_{Seed} \times \ln FSIZ$	0.2265*	1.90
$\ln P_{Fertilizer} \times \ln FSIZ$	0.4106	1.21
$\ln P_{Labor} \times \ln FSIZ$	- 1.2648***	- 3.13
$\ln P_{Pesticide} \times \ln FSIZ$	0.1024	1.16
Variance Parameters		
$\sigma^2 = \sigma^2_v + \sigma^2_u$	2.5267***	8.70
$\gamma = \sigma^2_u/(\sigma^2_v + \sigma^2_u)$	0.9892***	327.22
Log-likelihood	- 209.9237	
N	328	

Note: ***, ** and * are statistically significant at 1%, 5% and 10%, respectively. Source: survey data (2013)

Table 2. The estimation of farmers' profit-loss in hybrid rice production

Item	Mean	Min	Max	Std. Dev.
Profit efficiency (score)	0.63	0.01	0.95	0.26
Actual profit (USD/ha)	621.02	3.81	1,677.14	364.39
Profit-loss[8] (USD/ha)	325.46	43.06	1,885.71	247.87
Potential profit[9] (USD/ha)	946.48	380.95	2,277.17	319.71

Source: survey data (2013)

[8] Profit-loss = Actual profit * (1-Profit efficiency)/Profit efficiency
[9] The average potential profit is computed by formula: the potential average profit = actual profit + profit-loss.

Table 2 shows the estimation of the profit-loss, actual profit, and potential profit of farmers' hybrid rice production. It can be seen clearly that with the average actual profit of hybrid rice production that farmers achieved is 621.02 USD/ha and the average profit efficiency is only 0.63, then rice farmers incur profit-loss of around 325.46 USD/ha. This indicates that the average potential profit of hybrid rice that farmers could reach by the improvement of technical, allocative, and scale efficiencies is about 946.48 USD/ha. This is a significant amount of income for hybrid rice farmers in Central Vietnam. Therefore, the policies to enhance profit efficiency of hybrid rice are necessary and practical to eradicate poverty and increase rice farmers' income.

3.2 Factors contributing to profit inefficiency

The parameter estimates of the explanatory variables for the profit inefficiency and their t-tests are shown in the Table 3. The explanatory variables are hypothesized having a negative effect on the profit inefficiency of farmers' hybrid rice production except for age of household head.

Table 3. Parameter estimates of profit inefficiency model

Variable	Coefficient estimates	T-statistics
Constant	11.4725***	6.38
Age of the household head (year)	0.0779***	3.05
Household size (person)	- 0.0689	- 0.62
Educational level of the household head (year)	- 0.2288***	- 3.72
Farming experience of the household head (year)	- 0.0044	- 0.14
Rice-cultivated area of the household (ha)	0.1761**	2.39
Irrigation (%)	- 0.0674***	- 3.82
Share of rice income in household's total income (%)	- 0.0705***	- 5.98
Share of rice for sale (%)	0.0254**	2.66
Share of hybrid rice area (%)	- 0.0528***	- 3.71
Frequency of training attendance about hybrid rice production (number)	- 0.5371***	- 4.08
Hybrid rice production experience of the household head (year)	- 0.6877***	- 8.79
Number of family labors for hybrid rice production (person)	- 0.5081**	- 2.14
D1_Topography of the farm (1 = Lowland, 0 = otherwise)	- 2.6933***	- 5.51
D2_Type of seed (1=3 lines, 0=2 lines)	- 0.6186	- 1.19
D3_Source of seed (1=Domestic, 0=otherwise)	- 0.9432	- 1.09

Note: ***, ** and * are statistically significant at 1%, 5% and 10%, respectively. Source: survey data (2013)

The estimation results illustrate that almost all of explanatory variables have the expected sign except for farm size and share of rice for sale. As can be seen that age, educational level, irrigation, share of rice income, share of hybrid rice area, frequency of training attendance about hybrid rice production, hybrid rice production experience, and topography of farm are the key factors affecting farmers' profit inefficiency in hybrid rice production (statistically significant at 1%). Particularly, the older the farmer is, the more inefficiency he performs. By contrast, the profit inefficiency can be reduced if the education level of household head increases. Similarly, improvement in irrigation, the increases in share of rice income, share of hybrid rice area, frequency of training attendance about hybrid rice production, and experience of hybrid rice production, respectively are ways to reduce the profit inefficiency. It is also found that rice farmers in the lowland operate more efficiently by 2.69% than farmers in the upland do.

Conclusions and implications

This paper reveals that hybrid rice production in Central Vietnam is not efficient on average, about 0.63 due to the effects of age, low educational level, irrigation system, share of hybrid rice area, frequency of training attendance about hybrid rice production, hybrid rice production experience, and topography of farm.

The findings from investigating the determinants of profit inefficiency imply that in order to improve the profit efficiency of hybrid rice farming, hybrid rice farmers should actively attend the training and learn experience about hybrid rice production from well-performed farmers as well as promote hybrid rice intensive production, especially for three-line hybrid rice. Besides, government should have policies to improve socio-economic conditions of this area such as enhancing education and improving irrigation system, especially in the uplands and among poor farmers. In addition, government should also have policies to promote the adoption of high-quality hybrid rice varieties such as the three-line hybrid rice seed. Last but not least, the support policies to increase training about hybrid rice production and organizing the programs of visiting and learning experience from well-performed farmers are suggested to decrease the profit inefficiency of hybrid rice production.

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